BORON tubes pick up

[redacted]

[redacted]

18 April 1966

To: [redacted]

cc: Messrs. [redacted]

Subj: NRL Test Results on Use of Boron Filament Composites as Armor Plates

It will be recalled that two specimens of boron filament composites which were fabricated and processed by UTC were recently made available to the Naval Research Laboratory (NRL) for evaluation testing as armor piercing materials. One specimen was constructed of 130 plies of unidirectional wafers stacked alternately 90° to each other, while the other specimen was constructed with chopped random fibers, 1/2" to 3/4" long, sandwiched between 17 plies of wafers.

Mr. H. Ferguson, NRL, advised this date that the evaluation tests have been conducted on both specimens. For these tests of the boron filament composites, a Duron backing was included in the same manner as that observed in the testing of currently-used ceramic panels such as alumina. The evaluation tests were conducted using a 30 caliber armor piercing projectile. One specimen was tested at a projectile velocity of approximately 3500 ft/second, and the other specimen at a velocity of nearly 2800 ft/second. In both tests it was observed that the 30 caliber projectile penetrated directly through the boron filament composite without any shattering of the adjacent material. Consequently, it does not appear as if the boron filament composite holds much promise as resistant material for armor piercing projectiles. However, such materials may have some protective resistance to fragmentation attacks. If [redacted] is interested in evaluation of boron filaments composites for such use applications, NRL (Mr. Ferguson) would be most willing to conduct fragmentation tests on any samples which [redacted] desires to provide.

[redacted]

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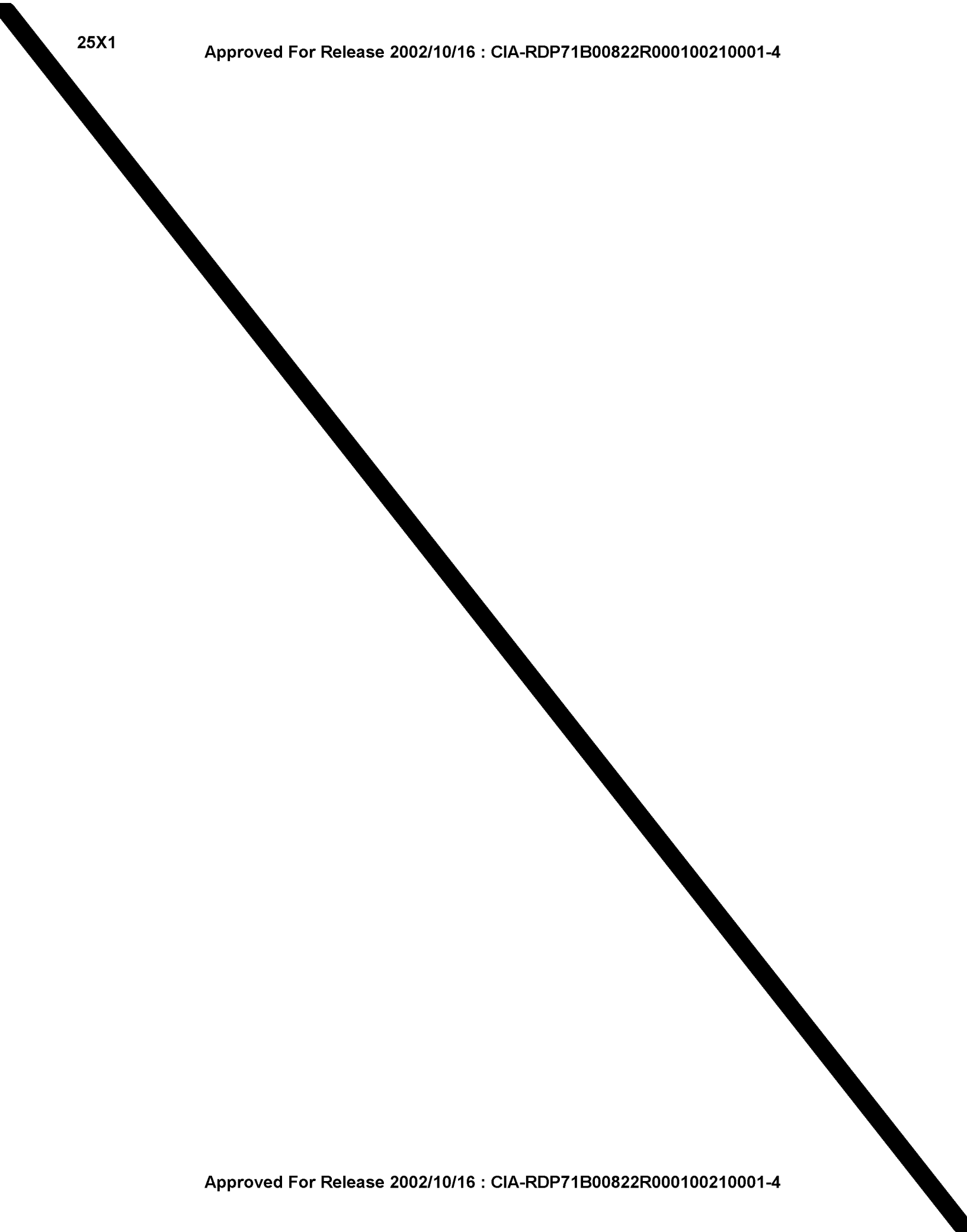

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[redacted]

INTERNAL MEMORANDUM

2

Control No.

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Key Words Boron Coating

KANIGEN COATING OF ELEMENTARY BORON

Of the many different materials which can be contemplated for use in mirror blanks, boron has an advantage of relatively low density.

Amorphous boron	2.3
α - rhombohedral	2.46
Tetragonal	2.31
β - rhombohedral	2.35

Around room temperature, boron is very stable chemically. It is, however, rather difficult to form because of great hardness, 9.3 Mohs scale and 2600 Knoop scale (K_{100}).

25X1 At the request of [redacted] the undersigned submitted a piece of elementary boron for nickel coating. The piece was round, 1" diameter and 1/2" thick. It was gray-black, polished to a shine on one side, and contained a great number of surface imperfections in the form of pits and cracks.

Contact was made with [redacted] 25X1

25X1 [redacted] who was willing to let their laboratory try to put on a Kanigen-nickel coating. The piece was returned with a 10 mil nickel coating applied. There had been a few difficulties because of the surface unevenness of the piece. The Kanigen process being an electroless method demands a metallic catalyst and preferably the substrate itself. In this case boron with its high resistivity ($\rho = 4 \times 10^6$ ohm cm) is not suitable and palladium was used as the catalyst. The palladium was added to the hypophosphate solution of the plating bath. Some concern was raised by the coating engineers of the difficulties to obtain

25X1

[redacted]

25X1 [redacted]

an even coating because of the state of the piece. The common Kanigen-nickel coating is about 1 - 2 mils thick. Evidently it was felt safer to go all the way to a 10 mil coating. The coating reflects the character of the surface but the coating process added numerous new small bubbles or elevations.

It should be pointed our that elementary boron has a thermal expansion of 8×10^{-6} cm/cm per °C and Kanigen nickel 13×10^{-6} cm/cm per °C. This difference in thermal expansion can be important for the dimensional stability of a boron mirror with such a heavy nickel coating even if it could be applied only 1 mil thick.

For curiosity an x-ray diffraction pattern was run of the Kanigen coating. It showed a single, very wide peak at d = 2.01 A, which is the main peak of nickel. A few interesting points were answered with this test. One, the coating is crystalline and composed of very fine crystals which shows up in the very wide peak and general characteristics of the x-ray pattern. Secondly, the Kanigen nickel is, according to chemical analysis, composed of:

Nickel	90-92%
Phosphorous	8-10%
Impurities	0.05%

Nickel phosphide (Ni_3P) is supposed to be formed and is precipitated, when the coating is heated at 400°C. This precipitation reaction is a step in the process and gives hardness to the coating. No nickel phosphide was found.

The experiments show that Kanigen nickel can be applied on elementary boron.

[redacted]

25X1

December 13, 1965

6 July 1965

Dear Bob,

This confirms our telephone conversation of today. We find three possible applications for the Boron filament material: (1) structures; (2) pressure vessels; (3) mirrors. The desirable properties for each application are somewhat different.

Generally speaking, we want to have all of the usual mechanical and thermal coefficients for both the single filaments and the epoxy-filament panels. For mirrors, we are particularly interested in the microstructure of the lay-up of panels, and we must know a great deal about the creep resistance in and out of the plane of the panel. Quite frankly we are very fearful of epoxys in optical elements, based on a considerable amount of bad experience.

We are also very interested in what happens to these structures in hard vacuums for any of the possible applications.

Finally, we understand, from other sources, that a subsidiary of Texaco and also United Aircraft are involved in the Boron fiber business. To what extent are they competitive with this source and to what extent are they complimentary?

The best way to get the desired information is a direct visit, and by copy of this letter, Thursday morning the fifteenth of July in San Diego is suggested as a date convenient to both you and I.

Best regards

Milt

Milt

mb

25X1

cc: [redacted]